Improvement of Nursing Workload by a Novel User-Aimed Assessment Software in a Tertiary Care Hospital

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(Received February 28, 2022, accepted August 3, 2022)
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Abstract Background: Expanding nursing workload is a worldwide problem. However, any nursing workload assessment (NWA) tool requires complicated analyses of the nursing job profile. To determine the imbalance in time assignments across all nursing operations and to reduce nursing workload, a nursing job survey was conducted. **Methods:** A total of 25 major job categories, common to all hospital wards, were identified, and an NWA tool was developed for efficient analyses to feature easy/flexible entry of the time spent for each job category and real-time visual profiling of job time allocation. The profile could be divided by job categories, wards, shifts, and years. **Results:** From the preliminary analyses, undesirable time allocation was revealed in several job categories, especially the time for recording and other nonessential nursing operations. Using the analytical functions of the NWA tool between 2014 and 2016, a series of corrective measures were successfully taken to many job categories, and they were found to be effective. Consequently, excessive overtime workload was reduced from 125 min/day/nurse in 2014 to 100 and 100 min/day/ nurse in 2015 and 2016, respectively. **Conclusion:** Notable improvements in nursing workload and time allocation for attentive patient care could be achieved employing the novel user-aimed NWA tool.

Key words: nursing workload, assessment tool, job categories, corrective measures, overtime work

Introduction

Nursing jobs cover a wide variety of operations, which thereby increases the nursing workload continuously at an unprecedented rate in Japan. Thus the Japanese Nursing Association reported that the duration of overtime work in acute care hospitals (400-599 beds) was 25.4 hour/month/person in 2008 (Japanese Nursing Association, reported in 2010).[1] Our prefectural general hospital has included a total of 504 beds, 19 departments, and 9 general wards with a patient-to-nurse ratio of 7:1 since 2011. Nurses' overtime work reached 26.5 hour/month/person in 2014.

Conversely, the overload experienced by nurses was reported to be correlated with the frequency of adverse events and accidents

among patients.[2-4] Therefore, a fundamental review of nurses' work burden is essential to effectively implement corrective measures. Under these circumstances, we aimed to alleviate nursing workloads at the headquarters of the nursing department, as a part of reformation projects in our hospital.

In this report, the utility of a novel user-aimed nursing workload assessment (NWA) tool (software) was evaluated by observing work profile changes in nursing operations in our hospital.

Methods

1. Study design

This was an observational study conducted in the form of a survey to assess the status of routine nursing jobs from 2014 to 2016. The NWA tool was developed with an advanced user interface and real-time analytical functions of work time profiles, which would analyze all job categories, wards, shifts, and years. All nurses working in our medical center were requested to participate in the survey. Table 1 displays the number of daytime nurses who collaborated and worked for more than 6 hour/day/nurse for 3 calendar consecutive days in November or December each year. The survey using the NWA tool was conducted as a part of reformation projects of our hospital. This study was waived from the review by Institutional Review Board of our hospital, because the survey was conducted anonymously as a part of job duty without including personal information.

2. Hierarchical classification of nursing jobs

For a comprehensive listing of nursing job categories, the K-J method was implemented by a collaboration of the managerial staff nurses.[5] It was a card-based brainstorming session that listed up ideas and hierarchically sorted them. As a result, 25 nursing job categories common to all wards were identified (see Table 1), which were further divided into a total of 65 nursing job subcategories.

3. Development of an NWA tool

The NWA tool was designed for easy/flexible entry of the time spent across all job categories and for comprehensive analyses with

real-time visualization of the survey results. It was implemented in a well-secured closed-network environment of the hospital information system and was made accessible from PC terminals at any section of the hospital (Fig. 1). It was developed incrementally over the 3-year in collaboration with the medical informatics department, using Apache 2.1 (a Web server software) and php 5.6 (a web-programming language).

3.1 User interface

The entry function was developed to register the spent time based on the 25 classifications of nursing job categories in minutes over the entire period of each shift work. For easy registry, the user interface was designed to provide hour-to-hour stepwise entry (Fig. 1). By selecting major job categories, a set of time entry fields for the corresponding job subcategory appeared. The entry was made easy by clicking the time up and down buttons. The interface issued a warning when a time summed across the selected items did not add up to 60 min for each frame of an hour. The tool monitored the user's entry pattern and assisted her/his entry by prediction. Clicking the "submit" button allowed a visual overview of the entry from a time-map view, and any incomplete entry was informed to each nurse. The NWA tool provided visualization of the real-time progress of the nurses' entry in all hospital sections so that the chief nurse could send a reminder to whom the entry was delayed.

3.2 Analytical tool: Filtered view of the work time profile

As a real-time analytical function, the TWA tool provided cross-reference tables and graphs that showed a profile of the accumulated time stratified by job categories. The tables and graphs could be filtered according to hospital sections, type of shift work, job experience in years, or job position upon clicking the corresponding filter buttons. The mapped work time profile was shared electronically among supervising nursing staff in real-time for review at each section/ward.

The NWA tool provided compact bar-chart graphs of year-to-year changes in the time spent for each job category collectively

Table 1 Average work time allocated to the 25 major job categories over the 3 years.

Year (Number of Nurses per Day)	2014 (277)	2015 (301)	2016 (268)
1. Recording	129.9	95.8	97.6
2. Management	80.5	77.9	79.7
3. Observation/Measurement	66.0	66.2	63.8
4. Conference	56.8	65.8	66.1
5. Admission/Discharge	47.3	42.6	49.5
6. Drug processing	43.5	43.2	47.6
7. Cleanliness/Body care	30.0	30.1	25.1
8. Meal	26.1	23.6	21.4
9. Job transfer	23.4	23.8	23.6
10. Transportation	20.9	14.1	16.9
11. Assist doctors	20.6	15.9	15.8
12. Contact/Communication	17.4	22.6	20.4
13. Excretion assist	16.9	14.8	14.0
14. Patient comfort	15.7	15.4	19.2
15. Patient safety	14.2	17.5	16.7
16. Ordering/Documentation	10.0	16.4	15.9
17. Environment/Cleaning	8.2	5.0	5.1
18. Regional cooperation	6.6	5.9	6.1
19. Respiratory/Cardiac care	5.7	7.2	5.9
20. Patient guidance	4.7	6.5	6.9
21. Medical goods management	4.7	3.9	4.1
22. Independence support	2.6	5.1	4.4
23. Staff/Student guidance	2.8	4.3	4.8
24. Medical device maintenance	2.5	2.1	2.3
25. Messenger work	1.7	1.6	1.8
Total	659	627	635
Duration of daytime	534	527	535
Duration of overtime	125	100	100

Number of nurses per day: Mean number of the nurses per day for 3 days in each year, who participated and worked more than 6 hours/day at nine wards in the survey. The unit of listed values is min/day /nurse.

Duration of daytime in 2015 was shorter than those in 2014 or 2016, because of the difference in constitution of nursing stuffs, whose working pattern was different, such as 7.75, 7.0, 6.5, 6.0 hours/day. Additionally, total working time in 2016 (635 min/day/nurse) was prolonged from that in 2015 (627 min/day/nurse), because the Ministry of Health, Labor, and Welfare required new administrative jobs such as the detail of nursing requirements for each patient on admission.

for all wards (Figs. 2 and 3). Then, real-time analysis of the trend was conducted by showing a between-year change index or standard deviation ratio (SDR) (Fig. 3; see Statistical Analyses, 3.4).

3.3 Corrective measures taken to reflect the preliminary survey results

Managerial meetings were held to think over measures to alleviate the workload of job categories that required too much time. The most time-consuming job category was nursing care recording (Fig. 2), as identified by the preliminary study in January 2014. The following were a series of corrective measures chronologically adopted by consensus.
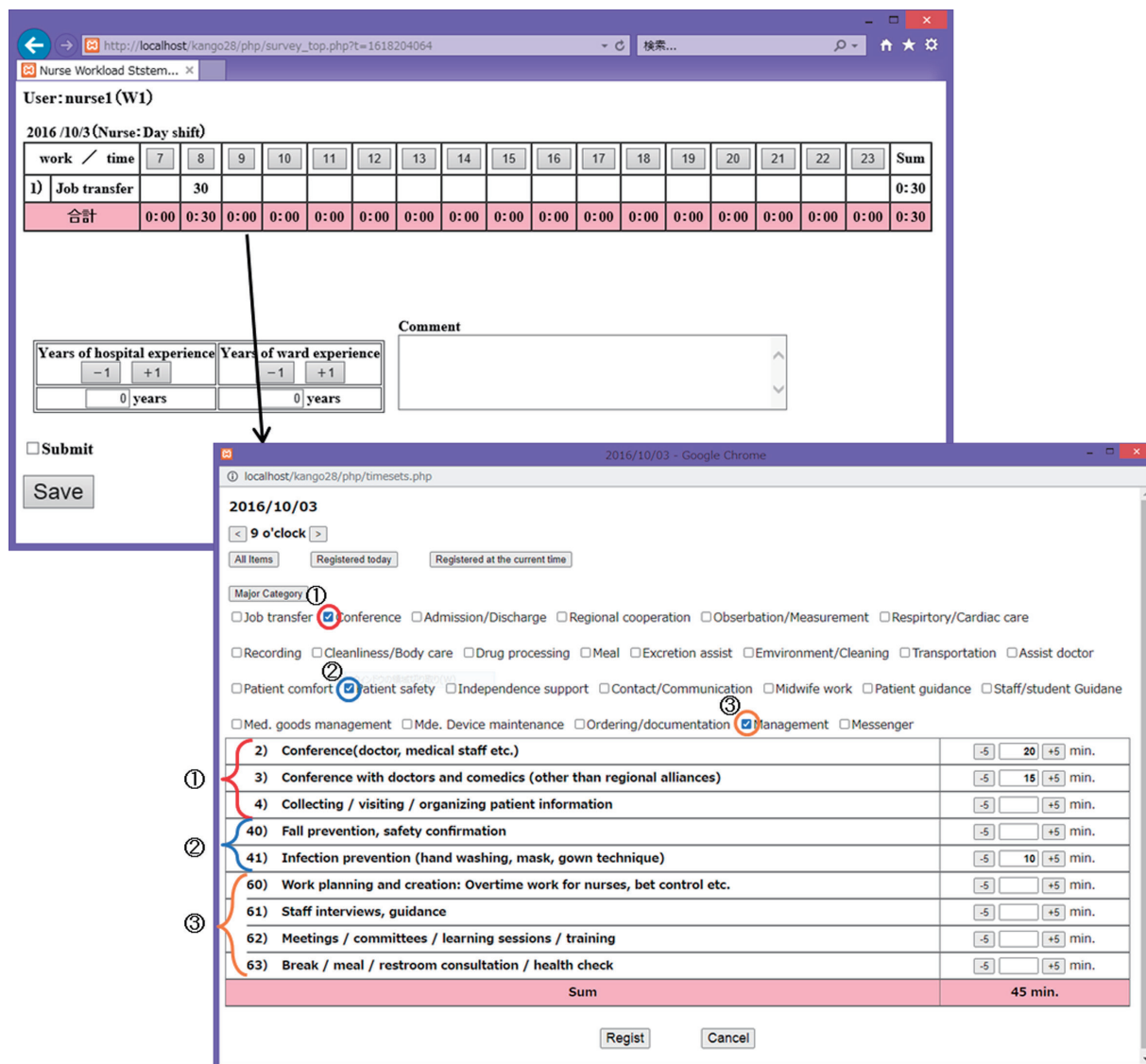
Fig. 1   Example of user interfaces in the nursing workload assessment (NWA) tool designed for efficiently categorized time entry in the workload survey.

The NWA tool was designed for easy/flexible entry of the time spent across all job categories and for comprehensive analyses and real-time visualization of the survey results. It was developed using Apache 2.1 (a web server software) and php 5.6 (a web-programming language). Refer to the main text for detail.

3.3.1 Supply Processing Distribution system

The preparation of medical and nursing devices/materials was delegated to the suppliers by adopting the Supply Processing Distribution (SPD) system that optimized the logistics processing of medical consumables in June 2014.

3.3.2 Admission/Discharge Support Center

The center obtained demographic and medical information from the patient and registered it as ready for use in nursing operations at each ward. This center, consisting of three nurses, one clerical officer, and three outsourced staff, was newly opened in June 2014 and established in December 2014.

3.3.3 Delegation of miscellaneous operations to nursing assistants

Patient's oral care, meal delivery, and bedmaking and cleaning were delegated stepwise

	Sum	W1	W2	W3	W4	W5	W6	W7	W8	W9	CV(%)
1: Recording	129.9	93	106	132	92	151	135	182	140	136	68.4
2: Management	80.5	114	82	84	67	81	76	77	86	62	131.5
3: Observation/Measurement	66.0	72	54	72	48	65	63	85	65	73	74.6
4: Conference	56.8	52	41	69	46	44	79	63	57	59	56.6
5: Admission/dscharge	47.3	42	34	50	64	66	35	42	68	27	108.1
6: Drug processing	43.5	38	43	42	43	39	67	51	22	47	73.4
7: Cleanliness/Body care	30.0	16	32	19	65	11	29	18	36	40	113.5
8: Meal	26.1	6	36	5	45	30	23	13	33	39	94.5
9: Job transfer	23.4	27	20	35	19	19	24	18	21	28	58.4
10: Transportation	20.9	18	31	18	23	18	19	12	11	37	136.0
11: Assist doctor	20.6	30	43	15	12	32	7	10	30	8	193.3
12:Contact/Communication	17.4	32	16	15	17	11	20	15	13	20	137.6
13: Excretion assist	16.9	14	18	18	29	6	25	10	7	23	109.4
14: Patient comfort	15.7	14	21	6	29	6	16	15	21	13	134.8
15: Patient safety	14.2	15	29	3	19	25	9	10	13	5	138.7
16: Ordering/documentation	10.0	11	13	8	8	11	11	8	10	9	141.4
17: Envionment/Cleaning	8.2	13	4	7	17	6	7	2	7	10	134.2
18: Regional cooperation	6.6	6	2	8	6	4	9	7	12	5	170.3
19: Respirtory/Cardiac care	5.7	1	7	3	5	15	8	2	4	5	207.6
20: Med goods management	4.7	5	3	1	9	8	2	1	8	6	235.4
21: Patient guidance	4.7	5	3	2	4	11	4	1	6	6	221.9
22: Independence support	2.8	2	3	1	6	4	3	1	3	2	250.3
23: Staff/student guaidance	2.6	2	0	2	0	4	5	1	4	4	301.2
24: Med device maintenance	2.5	1	3	5	1	6	0	1	4	1	370.1
25: Messenger	1.7	1	2	0	6	2	1	1	1	1	594.1

Fig. 2   Ward-by-ward breakdown of average nursing work time for 25 major job categories in 2014.

The X-axis represents the average time (min/day/nurse) spent in each job category (green bar in the leftmost column, sum) or each ward (red bar). Green bar in the rightmost column represents the coefficient of variations of the averages (CV%) for each job category.

to nursing assistants, whose number increased to 2-5 per ward by April 2015.

3.3.4 Nursing care recording
From the analysis of subcategories under recording, the majority of time was spent keeping anthropometric charts, nursing care notes, checking doctor's orders, and grading nursing care needs. Furthermore, there were duplicated recordings of physical measurements into both anthropometric charts and nursing care notes. To address the issue, the following corrective measures were introduced: (a) an awareness campaign to avoid duplicate entries, (b) multiple new clinical path menus for quick entry of nursing operation plans, (c) a fixed recording time for fresh nurses to assist their record-taking, and (d) an automatic entry device (blood pressure, pulse rates, body temperature, percutaneous oxygen saturation, and blood glucose at bedside. The HR Joint System™. 14T092-1K L1402, Terumo Corporation) was adopted in all wards in May 2015.
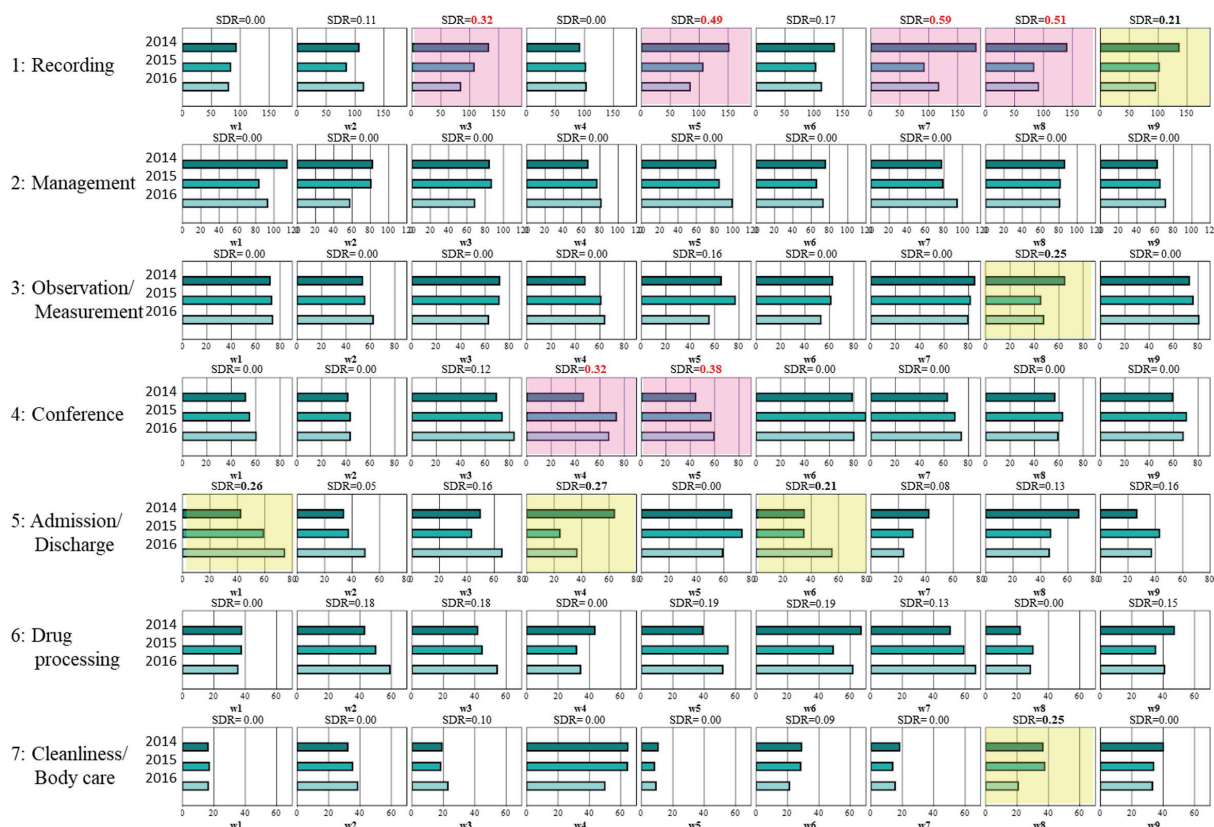
Fig. 3 Changes in the average work time in nine wards for seven leading job categories over the 3-year survey period.

The x-axis (green bar) represents the average time spent in min/day/nurse in each ward. The magnitude of between-year changes in the average work time for each ward was calculated as standard deviation ratio (SDR) by one-way ANOVA (refer to the main texts for detail). An SDR of ≥0.3 (red shade) implies a remarkable decrease or increase with high statistical significance (P < 0.001), whereas an SDR of ≥0.2 (yellow shade) implies a noticeable decrease or increase.

3.3.5 Pharmacists in the ward

The jobs of checking brought-in drugs and guiding self-injection drugs were gradually delegated to pharmacists, and at least one pharmacist per ward was ensured by July 2015.

3.3.6 Acute-phase rehabilitation

It was gradually delegated to physical therapists, whose number increased from 11 to 33 from 2014 to 2016, respectively.

3.4 Statistical analyses

The time, spent by all nurses belonging to a given ward for each job category, was recorded for 3 years. The analyses of the magnitude of the year-to-year variations in work time for each nursing job category were presented as a standard deviation ratio (SDR), based on one-way ANOVA using the following scheme.[6] In detail, between-year variation of collective job time was computed as a between-year standard deviation (SDbtw-yr), and an average within-year standard deviation was computed as SDwtn-yr. The SDR was computed as their ratio, that is, SDbtw-yr/SDwtn-yr.[6] It is of note that the coarse between-year SD computed by the ANOVA contains within-year SD, and thus SDbtw-yr in calculating SDR was the pure component of SDbtw-yr which was subtracted from a within-year component of SD (SDwtn-yr). Hence, SDbtw-yr was set to zero when pure SDbtw-yr was below SDwtn-yr. The threshold of

SDR = 0.3 is commonly used to analyze the magnitude of between-group variations. This study has adopted SDR of ≥0.3 as a remarkable between-year change and SDR of ≥0.2 as a noticeable between-year change.

Results

1. Workload analyses across nine wards in 2014

Fig. 2 presents the output from the NWA tool, showing an average work time, spent for 25 job categories across nine wards in 2014. The categories are sorted in descending order of total time (min/day/nurse) per category. The highest duration of time spent per day per nurse was in Category 1: Recording (129.9 min). Other categories requiring a longer job time were Categories 2: Management (80.5 min); 3: Observation/Measurement (66.0 min); 4: Conference (56.8 min); 5: Admission/ Discharge (47.3 min); 6: Drug processing (43.5 min); and 7: Cleanliness/Body care (30.0 min). The proportions of the allocated time among these job categories were the same regardless of the wards (Fig. 2). Between-ward variation of the average time was not large with a coefficient of variations (CV) between 56.6% and 136.0 % in the top 10 categories (Fig. 2).

2. Effects of corrective measures on the work time profile in 2015 and 2016

2.1 Apparent effects

The average time, spent for all 25 nursing job categories over the 3 years in all nurses who completed the survey, are listed in Table 1. By implementing the above corrective measures, the most prominent change was observed, as a reduction of the recording time (Category 1) from 129.9 min/day/nurse in 2014 to 95.8 and 97.6 min/day/nurse in 2015 and 2016, respectively. The average time, spent for the top 7 major job categories in nine wards over the 3 years are shown in Fig. 3. A remarkable decrease with SDR of ≥0.3 (red shade) or a noticeable decrease with SDR of ≥0.2 (yellow shade) was observed in the majority of wards upon the implementation of various measures.

2.2 Effects of paramedical staff support

Table 1 shows the effects of paramedical

staff support.

2.2.1 Delegation of miscellaneous operations to nursing assistants

Increased number of nursing assistants led to a reduction in the time spent for 8: Meal (26.1→23.6→21.4 min/day/nurse); 13: Excretion assist (16.9→14.8→14.0 min/day/ nurse);17:Environment/Cleaning(8.2→5.0→5.1 min/day/nurse); and 10: Transportation (20.9 →14.1→16.9 min/day/nurse) from 2014 to 2016, respectively (Table 1).

2.2.2 Pharmacists in the wards

As for jobs associated with drug preparation and administration (6: Drug processing), they did not significantly reduce despite the increased attendance of pharmacists in the wards with an average assigned time of 43.5→43.2→47.6 min/day/nurse over the 3 years (Table 1).

2.2.3 Admission/discharge control center

The establishment of the center led to a reduction in the time spent at the ward for the job Category 5: Admission/Discharge from 47.3 min/day/nurse in 2014 to 42.6 min/day/ nurse in 2015. However, it increased to 49.5 min/day/nurse in 2016 (Table 1).

2.2.4 SPD systems

The adoption of the SPD system slightly reduced the time for nurses in 21: Medical goods management (4.7→3.9→4.1 min/day/ nurse) over the 3 years (Table 1).

2.3 Allocation of more time to the qualified nursing cares

The improved nursing workload was moved to qualified nursing care (Table 1). Most prominently, the time was allocated to 12: Contact/Communication with patients (17.4→22.6→20.4 min/day/nurse) and 15: Patient's safety (14.2→17.5→16.7 min/day/ nurse) over the 3 years. The time to interact with patients also generally increased for Categories 20: Patient guidance and 22: Independence support. However, the time allocated to Categories 3: Observation/Measurement, 7: Cleanliness/Body care, 14: Patient's comfort, and 19: Respiratory/Cardiac care, were maintained.

2.4 Duration of overtime work

The duration of overtime work decreased from 125 min/day/nurse in 2014 to 100 and 100 min/day/nurse in 2015 and 2016, respectively, mostly due to the elimination of duplicate recordings and the use of an electronic anthropometric entry system (Table 1, Duration of overtime).

Discussion

Nursing care quality has become a worldwide issue for both the healthcare system and nursing profession.[7] Because the range of nursing operations and responsibilities has expanded enormously recently, nursing care management could have a strong impact on the quality of nursing in clinical settings.[8,9] Furthermore, the relationship between the nurses' staffing and nursing care quality was examined to prevent healthcare-associated accidents. Hence, shortages of nurses negatively affected the nursing care quality and increased the risk of adverse events, such as medication errors and healthcare-associated infections.[7] Moreover, it has an impact on patient morbidity and mortality, and length of hospital stay, so the nursing care quality has ethical, legal, and cost implications.[10]

In Japan, the situation of rapidly expanding nursing roles was the same and caused a concomitant nursing shortage, that is, a so-called vicious cycle of increased workload leading to a decreased workforce and nursing care quality. In the present study, our objective was simply to reduce the nursing workload and reallocate more time to qualified nursing care.

1. Reduction of recording time

The duration allocated to recording/documentation of the nursing care (Category 1) was drastically reduced from 129.9 min/day/nurse in 2014 to 95.8 and 97.6 min/day/nurse in 2015 and 2016, respectively (Table 1). In Fig. 3, a remarkable decrease with an SDR of ≥0.3 (red shade) or a noticeable decrease with an SDR of ≥0.2 (yellow shade) was observed in the majority of wards upon the implementation of various measures, especially recording. The adoption of an auto-recording device for physical measurements

(HR Joint System™; 14T092-1K L1402, Terumo Corporation) and the elimination of duplicated recording particularly contributed to this reduction. However, wards (W2 and W6-8) showed that the average time decreased in 2015 but increased again in 2016. This is attributable to the addition of new recording items of patient safety requested by the Ministry of Health, Labor, and Welfare in Japan.

2. Support from paramedical staff

Other items used in workload reduction were the delegation of nonessential nursing operations to the relevant paramedical staff. Highly effective measures included the following items:

2.1 Delegation of miscellaneous operations to nursing assistants

Reduction of the time spent for categories 8 (Meal), 10 (Transportation), 13 (Excretion assist), and 17 (Environment/Cleaning) over the 3 years was achieved by increasing the number of nursing assistants.

2.2 Pharmacists in the wards

Jobs related to drug preparation/processing, Category 6 (Drug processing) were not significantly reduced, despite the increased attendance of pharmacists in the wards over the 3 years. This might be attributable to the increased time spent in appropriate drug preparation under the guidance of pharmacists.

2.3 Admission/discharge control center

The center obtained demographic and medical information from the patients and registered those for ready to use in nursing operations at each ward. Therefore, the time spent for those at each ward was shortened in 2015. However, the Ministry of Health, Labor, and Welfare required new administrative jobs such as the detail of nursing requirements for each patient on admission (at ward), which increased in 2016 (Table 1).

2.4 The SPD system

The adoption of the SPD system resulted in a slight reduction in time for Category 21 (Medical goods management) over the 3

years. Additionally, it was possible to clear the dead stock of medical goods.

3. Changes in duration spent for each category between 2014 and 2016

The time spent for each category was increased or decreased from 2014 to 2015 or 2016 by the applied strategies (methods: corrective measures, 3.3.1-3.3.6) in these years. Using analytical functions of the NWA tool, the series of corrective measures were successfully taken to many job categories and found to be effective.

4. Allocation of more time to qualified nursing cares

After implementing the corrective measures, allocation of more time to the qualified nursing care was observed in various job categories (Table 1). Most prominently, the time allocated to Categories 12 (Contact/Communication with patients) and 15 (Patient safety) increased, respectively. The time to interact with patients also generally increased in Categories 14 (Patient comfort), 19 (Respiratory/Cardiac care), 20 (Patient guidance), and 22 (Independence support).

5. Total working duration and overtime workload

Although additional data entry time of approximately 20 min/day/nurse for NWA was needed, the total work duration in daytime nurses at nine general wards was reduced from 659 min/day/nurse in 2014 to 627 and 635 min/day/nurse in 2015 and 2016, respectively (Table 1). Nevertheless, our slogan of ideal nursing, "provide high-quality nursing services as an advanced acute care hospital, with ample time to interact with patients," was somehow achieved by increasing the time for direct patient care in Categories 14, 19, 20, and 22, as described above (Table 1).

Overtime workload was reduced from 125 min/day/nurse in 2014 to 100 and 100 min/day/nurse in 2015 and 2016, respectively (Table 1), which significantly improved the work-life balance of our nurses.

6. Usefulness of the user-aimed NWA tool

Another reason for the successful reduction of nursing workload was achieved by the development of the NWA tool, which was well accepted as an easy/flexible entry tool for busy nurses (Fig. 1). It enabled efficient and accurate implementation of the survey and quick visualization of the workload profile, stratified by job categories, wards, shifts, job experiences, positions, and years. Such features were not available in conventional survey tools with a total lack of analytical functions. This situation was the same for the tools developed in Western countries that were intended for use just as scales of overall nursing workload, not of real-time visualization of categorized workload status profiles.

As for the generalizability of the NWA tool, it can be applied to tertiary acute care hospitals worldwide, because the range of nursing operations in those hospitals is essentially the same due to the standardized provision of healthcare services. Moreover, the NWA tool was successfully implemented in a Japanese university hospital in an effort for efficient nurse staffing.

7. Limitations

This study has several limitations. The survey of the nursing workload was conducted only for 3 calendar consecutive days of each year. The survey should be conducted at different times of the year and for longer periods to avoid any bias in the workload profiling for true validation of the NWA tool. Moreover, this study was performed in an advanced acute care general hospital. Therefore, the findings may not be applicable to other hospitals with different grade healthcare services. It was rather conducted as a preliminary study to develop a practical tool for nursing workload analyses. Therefore, future studies should evaluate the use of the NWA tool to improve nursing care services as an outcome study.

Conclusion

For efficient analyses of the ever-expanding nursing workload, an easy-to-use survey tool (software, the NWA tool) has been developed with the built-in capability of visualization across all job categories for each nurse. The NWA tool prepared real-time analyses of the work time allocation for the chief nurse

in the ward and the headquarter of the nursing department. Using the tool, undesirable time allocation was revealed in several nursing job categories, especially in recording anthropometric and nursing care notes, and in nonessential nursing operations that could be delegated to other multidisciplinary medical team members. Several corrective measures were found to be effective in the survey of subsequent years using the visual analytical functions of the NWA tool. The notable improvement included increased assignment of time for attentive care of patients, which met our goal of "providing high-quality nursing services as an advanced acute care hospital, with ample time to interact with patients."

Consequently, the duration of overtime work was reduced from 125 min/day/nurse in 2014 to 100 and 100 min/day/nurse in 2015 and 2016, respectively.

Acknowledgments

Conflict of Interest

The authors declare no conflict of interest.

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